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STUDIES ON SUBSTITUTE CONTAINERS FOR CANNED FISHERY PRODUCTS

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Explanatory Note

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PART I

It was evident even before the outbreak of the war with Japan, that the food container industry would have to decrease drastically its use of various critical materials. These included not only tin, but also steel, rubber, and organic coating ingredients such as tung and perilla oils; all of which are essential in the making of cans for heat-processed foods.

Substitute containers, devised to use a minimum of critical materials, had to meet a variety of requirements to be suitable for use in the wartime packing of heat-processed foods. Such containers had to be impervious, they had to be usable in ordinary canning equipment with the least possible amount of adjustment or replacement of machinery. In addition the containers would not be satisfactory if they were unsightly, if they produced "off" flavors in the product or if the cost were appreciably higher than for the container previously employed.

Although the packing of fruits, vegetables, and specialty products in glass had been increasing for some years before the war, only a very small quantity of glass containers was being used in the commercial packing of heat-processed fishery products, and therefore the canneries of seafoods were almost entirely lacking in the special machinery and other facilities needed for handling glass jars or any other containers except cans. Since the glass jars that had been found satisfactory for commercial food packing required tin-plated, steel tops, the canners of fishery products still would have been beset by the scarcity of steel and tin in any attempt to change to glass. In addition, during the war, the glass manufacturers soon were unable to meet fully the demands for jars and bottles.

For various reasons given, the seafood canners had little choice but to continue using cans, thus the problem of containers for heat-processed fishery products resolved itself into the task of devising suitable cans that would require the least amounts of critical materials. Among these, tin became the most crucial, in that with the loss of our principal sources, Malaya and the Dutch East Indies, it was estimated that only 17,500 long tons could be spared to the canning industry for 1942, as compared to the 29,000 long tons it had utilized in 1940.

Extensive prewar and wartime trials of plastics, resins, and laminated wood pulp fiber served only to demonstrate that cans made from these materials would not fit the needs of canners of heat-processed foods. Some aluminum cans had been used for seafood packing in Europe and to a very limited extent in the United States. However, the aluminum sheets used in making cans for heat-processed foods had to be much purer than for most other purposes, and the cans were quite expensive. In addition, there were handling difficulties in the canneries because aluminum cans were easily marred, discolored or bent and required finer adjustment of the double seamer. Furthermore, the demand of the airplane industry for aluminum led to a more critical shortage of this metal than either steel or tin.

The last recourse, then, was to continue to use the steel can; but to try, first, to reduce or eliminate the tin coating; second, to avoid the canning of foods that could reasonably be marketed without canning; and third, wherever possible to reduce the consumption of metal by requiring that the cans be more completely filled and that the packing of smaller sized cans be discontinued.

The second and third objectives were accomplished through the War Production Board order No. M-81; and the initial step toward accomplishing the first objective had already been undertaken before Pearl Harbor by reducing the weight of tin on the plate for food cans from 1.5 to 1.25 pounds per base box. (The base box is a bundle of 112 sheets of tinplate. Each sheet is 20 inches long by 14 inches wide.)

Prewar research had indicated that, of the many methods tested, two types of substitute treatments of the steel plates gave cans that showed promise as wartime containers for heat-processed foods. These treatments were electrolytic tin-plating, which required only one-third or less of the tin used in manufacturing the standard hot-dipped tinplate, and bonderizing, in which the steel plate was treated chemically and no tin at all was employed.

However, much remained to be done before cans made from these new plates could be utilized on a commercial scale. Information was required on the service life of the new containers when they were packed with various products. It was also necessary to find out how the flavor and other organoleptic characteristics of the different foods would be affected by the new cans, especially under adverse storage conditions.

In addition the steel mills had to bring the experimentally developed substitute plates into commercial production. It was necessary to build, and place in working order, entirely new equipment for the manufacture of electrolytic tin plate and chemically treated steel.

While the new plates were coming into commercial production the research departments of each of the various can companies prepared large numbers of experimental canned food packs, using various combinations of substitute plates. This program was coordinated by the Research Laboratory of the National Canners Association, which also prepared extensive packs. These packs were then held under various adverse storage conditions and the changes in the foods and the cans were observed periodically. These packs included fruit, vegetables, milk, and meat, but only one or two types of canned fishery products.

It could not be assumed that the experimental packs of one or two species of fish would furnish data that could be applied to every other canned fishery product. The can-making industry, however, was already faced by the immense task of studying the problems of packing other articles that were canned in larger amounts than fish; and was unable to undertake a more complete study of the suitability of the wartime containers for the canning of fishery products, especially since so many different species were involved and the numerous canneries were widely scattered, often in difficultly accessible locations. It was felt that the Fish and Wildlife Service could best make its contribution to the cooperative study by assuming the task of preparing and examining experimental packs of a wide variety of fishery products in cooperation with the National Canners Association.

The substitute container program of the Fish and Wildlife Service did not include all of the combinations of different types of experimental cans being tested for all types of products by the National Canners Association, but only those that previous research had indicated would be likely to be suitable for fishery products.

The cans included in the group that was subjected to tests with fishery products were as follows (the various descriptive terms are explained on page 2):

0.5 acid bath, melted electrolytic plate, plain bodies and ends.
0.5 alkaline bath, melted electrolytic plate, plain bodies and ends.
0.5 acid bath, melted electrolytic plate, inside-enameled bodies and ends.
0.5 alkaline bath, melted electrolytic plate, inside-enameled bodies and ends.
1.25 OPM plate, plain bodies, bonderized.
1.25 OPM plate, inside-enameled bodies, and ends.
1.25 OPM plate, plain bodies and ends.
1.25 OPM plate, inside-enameled bodies and ends.

The last two types listed were packed as controls, while the first two types were used only for the purpose of comparing the performance of the plate with and without inside enamel and not with the expectation that such light tinning would be employed commercially without the protection of inside enamel.

The substitute cans selected were tested with all of the heat-processed fishery products then commercially canned in the United States. All except one of the packs were prepared in commercial canneries; and standard procedures in handling, packing, processing, cooling, storing, and shipping were followed. Packs were made at Eastport, Jonesport, Portland, and Stonington, Maine; Gloucester, Mass.; Camden, N. J.; College Park, Md.; New Orleans, Houma and Grand Isle, La.; Monterey, San Pedro, and Long Beach, Calif.; Astoria, Oregon; and Willapa Harbor, Washington. A total of 191 packs of 33 different species was prepared under the 1942-43 program.

The packs of Pacific Coast products were made under the direction of the staff members of the Fishery Technological Laboratory of the Fish and Wildlife Service at Seattle, Wash.; the Atlantic and Gulf Coast packs were made under the direction of staff members of the Fishery Technological Laboratory at College Park, Md. Half of each pack prepared on the Pacific Coast and all the samples prepared on the Atlantic and Gulf Coasts were sent to the College Park laboratory. This gave a 3000to 4000 mile shipping test for products from the Pacific Coast, and about 600 to 1500 miles for the Atlantic and Gulf Coast products. The observational methods were checked by comparing the reports of the two laboratories on the two halves of the Pacific Coast pack.

Upon arrival at the College Park laboratory the samples were divided into two lots. One lot was held in incubator storage at a temperature of about 90° F., while the other was stored at room temperature, at approximately 70° F. Samples of each lot were withdrawn from storage and examined at approximately 30-day intervals. This examination was similar to that used in the other canning research laboratories, and was intended to determine the internal condition of the container, by noting the presence or absence of iron sulfide, tin sulfide, spangling, corrosion, or other signs of physical deterioration according to a standard grading scale. The headspace, external appearance, color, flavor, odor, and degree of vacuum were also noted, especially in relation to the condition of the plate or enamel.

In addition to the periodic physical and organoleptic examinations, a few chemical assays were made of the amounts of iron dissolved in order to determine, if possible, whether there was any correlation between the amounts of these metals dissolved in the product and the degree of deterioration of the container. Results indicated that the dissolved iron content was roughly proportional to the degree of internal corrosion of the container. The amount was not sufficient to be toxic even in the cans most heavily detinned. The minimum dissolved iron content was 6 p.p.m. The sample in this instance was pink salmon packed in 0.5 acid electrolytic melted plate, inside-enameled cans. The cans showed no visible traces of internal corrosion. The maximum dissolved iron content was 36 p.p.m. This result was obtained from a can of Manhattan style clam chowder, packed in 0.5 alkaline electrolytic melted plate, inside plain.

Approximate analyses were made of each of the packs canned under this program in order to determine the content of dry matter, protein, fat, and mineral matter. The results of the chemical analyses will be published in detail in a separate report.

Explanation of Abbreviations and Definition of Terms

1.25 OPM	- is a hot-dipped tin plate 1.25 lbs. tin per base box of metal. OPM refers to Office Production Management, which was the agency responsible for ordering this standard of plate.
0 .5 acid melt	- is an electrolytic tin plate, 0.5 lb. per base box, acid bath, melted (flow brightened) finish.
0.5 alk. melt	- is an electrolytic tin plate, 0.5 lb. per base box, alkaline bath, melted (flow brightened) finish.
elect.	- means electrolytic.
I.E.	- means inside-enameled.
plain	- means not inside-enameled.
enamel. bond.	- means enameled bonderized, that is, chemically treated black plate with enamel coating.

Scoring for Degree of Deterioration

Trace	-	indicates deterioration evident only after detailed examination.
Light	-	means that only a few scattered signs of sulfide darkening, detinning, or corrosion are evident.
Moderate	-	means that sulfide darkening, detinning, or corrosion covers less than one-fourth of the surface.
Severe	-	means that sulfide darkening, detinning, and other deterioration affect more than one-fourth, but not more than one-half, of the surface area.
Commercial failure	-	indicates that the inner surface of the plate has deteriorated to such a degree that a consumer opening the can would reject it. This classification differs from "days to first failure" used in other literature on the subject in not being determined by the outward appearance of cans as flippers or springers. As a rule, the terms "commercial failure" and "days to first failure", may be considered synonomous, but with certain products, especially sea herring and fish flakes in plain cans, the inside of the cans was entirely blackened, and more than half-detinned, before flippers or springers were noted.

Additional packs were made in the season of 1943-44 to test two new variants, namely, cans of 0.25 acid melted electrolytic plate, both sides enameled, side seam striped, and cans with bodies of 0.5 acid melted electrolytic plate, inside-enameled, and bonderized ends. Rechecks were also made of several products packed in the 1942-43 season, to test the validity of certain results previously obtained. The incubation period for these packs is not yet finished, and results will be reported later. Information obtained to date indicates that cans of 0.25 acid melted electrolytic plate, both sides enameled, should be satisfactory for most fishery products.

Summary of Observations

Data on the different canned fishery products have been summarized in a series of tables arranged in alphabetical order by product name. Although specimens of the different cans of each product were examined at approximately 30-day intervals, the tables list only the days to commercial failure plus the final remarks, except that additional notes are sometimes included on especially interesting data from the earlier examinations. The following observations are not intended to do more than serve as an explanatory supplement to the tables. To obtain greater detail on the history of the performance of the experimental plates with different fishery products reference should be made to the tables.

Alewives (River herring, New England): Table 1. The regular series of plates were used and in addition cans with enameled bonderized bodies and ends were also tried. All of the packs showed very rapid deterioration. The 1.25 OPM plate and the two types of electrolytic plate were declared commercial failures after 76 days' incubation at 90° F. The bonderized-plate cans became failures after 198 days at 90° F. While there was not much sulfide formation, there was complete peeling of enamel at the first examination, and all of the bonderized cans became hydrogen swells. This pack was made from frozen fish which showed evidence of oxidation when packed.

Can size: No. 300 (300 x 407). Process: 75 min. at 240° F.

Code	Date Packed	Plate: Bodies	Plate: Ends	Storage at 90° F.: Number of cans stored	Storage at 90° F.: Days to commercial failure	Storage at 70° F.: Number of cans stored	Storage at 70° F.: Days to commercial failure	Date pack discarded	Remarks
	1943							1943	
4605	June 15	1.25 OPM, IE	1.25 OPM, IE	25	76	25	116	Dec. 30	Cans in bad condition at first examination. Examinations were continued some time after commercial failure.
4604	June 15	0.5 acid melted elect. IE	0.5 acid melted elect. IE	25	76	25	76	Dec. 30	Do.
4603	June 15	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	25	76	25	76	Dec. 30	First examination showed light sulfide staining and complete peeling of enamel.
4602	June 15	Enameled bonderized	Enameled bonderized	25	198	25	198	Dec. 30	Moderate peeling of enamel on first examination. Did not become commercial failure until 12-30-43.

Clams, hard, Atlantic, whole in brine: Table 2. The alkaline melted electrolytic plate with inside enamel was the only one of this series to be classed as a commercial failure. The other plates showed a noticeable amount of sulfide staining beneath the enamel. Traces of peeling were found on the bonderized ends and their use is not recommended at present for these packs. Better results might have been obtained if the cans had had striped side seams.

Can size: No. 1 standard (211 x 400). Process: 30 min. at 240° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
		Bodies	Ends						
	1943							1944	
87	Jan. 26	1.25 OPM, IE	1.25 OPM, IE	48	No failure	48	No failure	Apr. 18	Sulfide staining beneath enamel in 90 days. Enamel began to peel after 9 months, light - did not become worn.
88	Jan. 28	0.5 acid melted elect. IE	0.5 acid melted elect. IE	48	No failure	48	No failure	Apr. 18	Sulfide stain beneath enamel - moderate in 90 days. Enamel peeling light in 5 months, but did not progress.
89	Feb. 3	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	48	329	48	363	Apr. 18	Sulfide staining moderate to severe.
90	Feb. 5	1.25 OPM, IE	Enameled bonderized	48	No failure	No failure	No failure	Apr. 18	Lighter sulfide staining than other packs. Traces of peeling of bonderized ends.

This series was packed in Fish and Wildlife Service Laboratory at College Park, Maryland.

Clams, hard, Pacific: Table 3. This product was packed in inside-enameled cans only. The alkaline electrolytic plate was judged a failure both after 160 days of incubated storage, and after 278 days at room temperature. There was noticeable sulfide staining beneath the enamel, to about the same degree as the Atlantic hard clams, but not to such an extent as to prohibit the use of the acid electrolytic plate or the bonderized ends.

Can size: No. 1 tall (301 x 411). Process: 120 min. at 240° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
		Bodies	Ends						
	1943							1944	
91	Mar. 9	1.25 OPM, IE	1.25 OPM, IE	24	No failure	24	No failure	July 21	Moderate sulfide stain beneath enamel, light peeling of enamel.
92	Mar. 9	0.5 acid melted elect. IE	0.5 acid melted elect. IE	24	No failure	24	No failure	July 21	Do.
93	Mar. 9	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	24	160	24	278	July 21	Moderate sulfide stain, complete peeling of enamel.
94	Mar. 9	1.25 OPM, IE	Enameled bonderized	23	No failure	23	No failure	July 21	Moderate sulfide stain beneath enamel, light enamel peeling on body and ends and at side seams.

Clams, razor, Pacific: Table 4. The razor clams were packed in inside-enameled cans only. The insides of all cans were still perfectly bright when the packs were discarded after storage. All of the substitute plates may be considered satisfactory for this pack.

Can size: No. 1 standard (211 x 400). Process: 34 min. at 232° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
		Bodies	Ends						
	1943							1944	
79	Apr. 9	1.25 OPM, IE	1.25 OPM, IE	23	No failure	23	No failure	July 22	No sulfide stains; traces of enamel peeling on body, side seam and ends.
80	Apr. 9	0.5 acid melted elect. IE	0.5 acid melted elect. IE	24	No failure	24	No failure	July 22	Do.
81	Apr. 9	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	24	No failure	24	No failure	July 22	No sulfide stains, light enamel peeling on body, side seam, and ends.
82	Apr. 9	1.25 OPM, IE	Enameled bonderized	24	No failure	24	No failure	July 22	No sulfide stains, traces of enamel peeling on body, side seam, and ends.

Clams, soft: Table 5. The 0.5 acid melted plate with inside enamel gave the best results of this series. All of the plates were satisfactory. There was no peeling of the bonderized ends.

Can size: No. 1 standard (211 x 400). Process: 20 min. at 240° F.

Code	Date Packed	Plate Bodies	Plate Ends	Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1943							1944	
126	Jan. 8	1.25 OPM, IE	1.25 OPM, IE	50	No failure	50	No failure	Apr. 12	Light peeling of enamel after one year.
127	Jan. 8	0.5 acid melted elect. IE	0.5 acid melted elect. IE	50	No failure	50	No failure	Apr. 12	Traces of peeling after one year.
128	Jan. 8	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	50	No failure	50	No failure	Apr. 12	Light enamel peeling after one year.
129	Jan. 8	1.25 OPM, IE	Enameled bonderized	50	No failure	50	No failure	Apr. 12	Light peeling of body enamel after one year, no sulfide stains

Clam chowder, Manhattan style: Table 6. The acid electrolytic plate, inside-enameled, gave the best results with this product. The plain plates showed considerable discoloration within a short time. While the discoloration did not progress very rapidly during the storage period, the chowder had a decidedly tinny flavor.

Can size: No. 1 standard (211 x 400). Process: 75 min. at 240° F.

Code	Date Packed	Plate Bodies	Plate Ends	Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1943							1944	
122A	May 19	1.25 OPM, plain	1.25 OPM, plain	51	187	51	224	July 19	The cans showed considerable darkening after 70 days.
123A	May 19	0.5 acid melted elect. plain	0.5 acid melted elect. plain	51	187	51	224	July 19	Most cans showed blue-black sulfide discoloration.
124A	May 19	0.5 alk. melted elect. plain	0.5 alk. melted elect. plain	51	187	51	224	July 19	More corrosion than 122A or 123A.
125A	May 19	1.25 OPM, IE	Enameled bonderized	51	No failure	51	No failure	July 19	Trace of enamel peeling on side seam.
122C	May 19	1.25 OPM, IE	1.25 OPM, IE	50	No failure	50	No failure	July 19	Trace of sulfide stain, no peeling of enamel.
123C	May 19	0.5 acid melted elect. IE	0.5 acid melted elect. IE	50	No failure	50	No failure	July 19	Light sulfide stain on body, traces of enamel peeling on side seam and body.
124C	May 19	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	50	No failure	50	No failure	July 19	Light sulfide stain on body, light enamel peeling on side seam.
125C	May 19	1.25 OPM, IE	Enameled bonderized	50	No failure	50	No failure	July 19	Trace of sulfide stain on body, light enamel peeling on bonderized ends.

Clam chowder, New England style: Table 7. The inside-enameled cans made from 1.25 OPM plate, the 0.5 acid melted electrolytic plate, and the 1.25 OPM plate with bonderized ends, were satisfactory. The alkaline melted electrolytic plate was not satisfactory because of heavy peeling of the enamel.

Can size: No. 1 standard (211 x 400). Process: 60 min. at 240° F.

Code	Date Packed	Plate Bodies	Plate Ends	Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1943							1944	
83	Jan.8	1.25 OPM, IE	1.25 OPM, IE	50	No failure	50	No failure	Apr. 12	Traces of sulfide staining; moderate peeling of enamel on body and side seam.
84	Jan. 8	0.5 acid melted elect. IE	0.5 acid melted elect. IE	50	No failure	50	No failure	Apr. 12	Light sulfide staining; enamel peeling light on body and moderate on side seam.
85	Jan. 8	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	50	347	50	392	Apr. 12	Moderate sulfide staining. Heavy peeling of enamel on body and ends.
86	Jan. 8	1.25 OPM, IE	Enameled bonderized	50	No failure	50	No failure	Apr. 12	Traces of sulfide staining; light enamel peeling on body but none on ends.

Crab, Dungeness: Table 8. The crab was packed in the inside-enameled cans only. A three-piece, parchment-paper wrapper was also used, a standard procedure in crab canning. All of the plates were apparently satisfactory at the end of the storage period. A very slight peeling of enamel occurred in the bonderized plate near the close of the storage period, but this was not sufficient to affect adversely the usefulness of the plate.

Can size: ½ flat (307 x 201.25). Process: 50 min. at 240° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1943	Bodies	Ends					1944	
110	Apr. 15	1.25 OPM, IE	1.25 OPM, IE	22	No failure	21	No failure	July 25	Light sulfide staining, traces of peeling on side seam only.
111	Apr. 15	0.5 alk. melted elect. IE	0.5 acid melted elect. IE	24	No failure	24	No failure	July 25	Light sulfide stains on body, moderate on ends. No enamel peeling.
112	Apr. 15	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	24	No failure	24	No failure	July 25	Light sulfide stains on body and ends. No enamel peeling.
113	Apr. 15	1.25 OPM, IE	Enameled bonderized	24	No failure	24	No failure	July 25	No sulfide stains, trace of enamel peeling on side seam and ends.

Fish chowder, New England (haddock): Table 9. The alkaline melted electrolytic plate with inside enamel was the only one of this series to be classed as a commercial failure. This was because of heavy sulfide staining and enamel peeling. Some enamel peeling occurred on the bodies and side seams of the other plates, almost always where fat had settled out of the chowder.

Can size: No. 1 standard (211 x 400). Process: 75 min. at 230° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1943	Bodies	Ends					1944	
130	Jan. 12	1.25 OPM, IE	1.25 OPM, IE	50	No failure	50	No failure	Apr. 18	Moderate to light peeling of enamel on body and side seams.
131	Jan. 12	0.5 acid melted elect. IE	0.5 acid melted elect. IE	50	No failure	50	No failure	Apr. 18	Light sulfide staining, moderate to light peeling of enamel.
132	Jan. 12	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	50	311	50	346	Apr. 18	Heavy sulfide staining; severe peeling on body, side seam, and ends.
133	Jan. 12	1.25 OPM, IE	Enameled bonderized	50	No failure	50	No failure	Apr. 18	Traces of sulfide staining, light peeling of enamel on body, side seam and ends.

Fish flakes: Table 10. The inside enameled cans made of 1.25 OPM plate, 0.5 acid melted electrolytic plate, and 1.25 OPM plate with enameled bonderized ends were satisfactory, with only light sulfide staining. The alkaline melted plate showed moderate sulfide staining and enamel peeling. It is probably inadvisable to use this plate for fish flakes. All of the plain cans showed considerable detinning, beginning with the first examination, and all were swells when the packs were discontinued.

Can size: No. 300 (300 x 407). Process: 80 min. at 240° F.

Code	Date Packed	Plate		Storage at 90 F. Number of cans stored	Storage at 90 F. Days to commercial failure	Storage at 70 F. Number of cans stored	Storage at 70 F. Days to commercial failure	Date pack discarded	Remarks
	1942	Bodies	Ends					1944	
69-C	Nov. 23	1.25 OPM IE	1.25 OPM IE	45	No failure	45	No failure	Apr. 11	Light sulfide staining after 8 months, light peeling at final examination.
70-C	Nov. 23	0.5 acid melted elect. IE	0.5 acid melted elect. IE	45	No failure	45	No failure	Apr. 11	Do.
71-C	Nov. 23	0.5 alk. melted elect. IE	0.5 alk. melt. elect. IE	30	No failure	30	No failure	Apr. 11	Moderate sulfide staining at end of year, moderate peeling.
72-C	Nov. 23	1.25 OPM IE	Enameled bonderized	45	No failure	45	No failure	Apr. 11	Light sulfide staining after 8 months, no peeling of ends.
69-A	Nov. 23	1.25 OPM plain	1.25 OPM plain	36	228	36	313	Apr. 11	Considerable detinning at first examination.
70-A	Nov. 23	0.5 acid melted elect. plain	0.5 acid melted elect. plain	36	149	36	274	Aug. 23, 1943	All cans swells 8-23-43.
71-A	Nov. 23	0.5 alk. melted elect. plain	0.5 alk. melted elect. plain	36	149	36	274	Aug. 23, 1943	Do.
72-A	Nov. 23	1.25 OPM IE	Enameled bonderized	45	No failure	45	No failure	Aug. 23, 1943	Light sulfide staining after 8 months; light peeling of enamel on body but not on ends.

Herring, river: Table 11. This series included only one plain plate, namely, 1.25 OPM. The inside-enameled plates showed little sulfide stain and only light peeling, but all of the cans became swells in 217 days even in room temperature storage. The herring had been in poor condition when canned.

Can size: No. 300 (300 x 407). Process: 55 min. at 245° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1943	
67-A	May 27	1.25 OPM, IE	1.25 OPM, IE	24	171	24	217	Dec. 30	Severe sulfide staining on body; severe peeling of enamel on body, side seam and ends.
67-C	May 27	1.25 OPM, plain	1.25 OPM, plain	24	217	24	217	Dec. 30	Sulfide staining moderate, corrosion light, but all cans swells.
68-A	May 27	0.5 acid melted elect. IE	0.5 acid melted elect. IE	24	217	24	217	Dec. 30	Sulfide staining moderate, peeling of enamel light, but all cans swells.
69-A	May 27	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	24	217	24	217	Dec. 30	Sulfide staining moderate, peeling of enamel moderate, all cans swells.
70-A	May 27	1.25 OPM, IE	Enameled bonderized	24	217	24	217	Dec. 30	Sulfide staining light, peeling of enamel light on bodies, side seams and ends; but all cans swells.

Herring, sea: Table 12. None of the plain containers was satisfactory. Even the cans made from 1.25 OPM plate showed very rapid deterioration. Cans of 0.5 acid melted, electrolytic plate, inside-enameled, which were packed at a somewhat later date, are apparently satisfactory after one year.

Can size: No. 300 (300 x 407). Process: 75 min. at 240° F.

Code	Date Packed	Plate		Storage at 90 F.		Storage at 70 F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1942							1943	
137	Nov. 12	1.25 OPM plain	1.25 OPM	48	124	48	152	July 6	Severe detinning noticed at first examination, before cans became commercial failure.
138	Nov. 14	0.5 acid melted elect.	0.5 acid melted elect.	48	124	48	152	July 6	Do.
139	Nov. 14	0.5 alk. melted elect.	0.5 alk. melted elect.	48	124	48	152	July 6	Continued examinations after commercial failure until all cans became hydrogen swells.
140	Nov. 14	1.25 OPM plain	Enameled bonderized	48	124	48	124	July 6	Slight peeling of bonderized ends.

Mackerel, Boston: Table 13. The inside-enameled cans made of 1.25 OPM plate, 0.5 acid melted electrolytic plate, alkaline melted electrolytic plate, and 1.25 OPM plate with bonderized ends, were satisfactory. None of the containers with plain inside, including the 1.25 OPM plate, was satisfactory, though deterioration was not as rapid as in the cans containing sea herring or fish flakes.

Can size: No. 300 (300 x 407). Process: 55 min. at 240° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1942								
32-C	Nov. 24	1.25 OPM IE	1.25 OPM IE	45	No failure	45	No failure	Apr. 11, 1944	No sulfide staining, light enamel peeling at time of discard.
33-C	Nov. 24	0.5 acid melted elect. IE	0.5 acid melted elect. IE	45	No failure	45	No failure	Apr. 11, 1944	Light sulfide staining, light peeling at end of period.
34-C	Nov. 24	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	30	No failure	30	No failure	Apr. 11, 1944	Light sulfide staining, moderate peeling.
35-C	Nov. 24	1.25 OPM IE	Enameled bonderized	45	No failure	45	No failure	Apr. 11, 1944	Light sulfide staining, moderate enamel peeling on body but not on ends.
32-A	Nov. 24	1.25 OPM plain	1.25 OPM plain	36	359	36	439	Apr. 12, 1944	All cans in incubator and 75% in room temperature storage became swells.
33-A	Nov. 24	0.5 acid melted elect. plain	0.5 acid melted elect. plain	36	174	36	268	Aug. 23, 1943	All cans became hydrogen swells.
34-A	Nov. 24	0.5 alk. melted elect. plain	0.5 alk. melted elect. plain	36	175	36	269	Aug. 23, 1943	Complete detinning.
35-A	Nov. 24	1.25 OPM IE	Enameled bonderized	48	No failure	48	No failure	Apr. 12, 1944	No sulfide staining, light peeling of enamel.

Mackerel, California: Table 14. The 1.25 OPM and 0.5 acid melted electrolytic plates, both inside-enameled, were the only cans considered satisfactory. Both the inside-enameled and plain 1.25 OPM cans with bonderized ends were failures because of heavy peeling of enamel on the ends. The alkaline melted electrolytic plate was also considered a commercial failure.

Can size: No. 300 (300 x 407). Process: 75 min. at 250° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
47-C	Jan. 20	1.25 OPM IE	1.25 OPM IE	24	No failure	24	No failure	July 18	Sulfide staining light, enamel peeling light.
48-C	Jan. 20	0.5 acid melted elect. IE	0.5 acid melted elect. IE	24	No failure	24	No failure	July 18	Sulfide staining light, enamel peeling light to moderate.
49-C	Jan. 20	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	24	208	24	208	July 18	Sulfide staining light, enamel peeling caused commercial failure.
50-C	Jan. 20	1.25 OPM, IE	Enameled bonderized	24	278	24	361	July 18	Sulfide staining light, enamel peeling severe on ends.
47-A	Feb. 3	1.25 OPM plain	1.25 OPM plain	24	208	24	361	July 18	Sulfide staining moderate, corrosion moderate, all cans swells.
48-A	Feb. 3	0.5 acid melted elect. plain	0.5 acid melted elect. plain	24	245	24	245	July 18	Completely detinned. All cans swells.
49-A	Feb. 3	0.5 alk. melted elect. plain	0.5 alk. melted elect. plain	24	245	24	245	July 18	Do.
50-A	Feb. 3	1.25 OPM, IE	Enameled bond. System No. 2	24	No failure	24	No failure	July 18	Moderate sulfide stain beneath enamel. Light enamel peeling on ends.
50-AA	Feb. 3	1.25 OPM IE	Enameled bond. System No. 1	24	Failure questionable	24	Failure questionable	July 18	Sulfide stain severe. Enamel peeling on ends severe.

Oysters, Atlantic: Tables 15 and 15A. These trials included two series of plain plates, each furnished by a different can company, and one series of inside-enameled plates. All of the inside-enameled cans were satisfactory, being free from sulfide discoloration and showing only traces of peeling at the close of the storage period. The 1.25 OPM plain cans with either plain or bonderized ends could very well be recommended, since they showed only light sulfide staining in spots. The acid and alkaline electrolytic plates without enamel did not show as much deterioration as when packed with other fishery products, but it was sufficient to be noticeable and objectionable.

Can size: No. 1 standard (211 x 400). Process: 13 min. at 250° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
95-C	Feb. 23	1.25 OPM, IE	1.25 OPM IE	40	No failure	40	No failure	Apr. 19	No sulfide staining, traces of enamel peeling appeared at end of storage.
96-C	Feb. 23	0.5 acid melted elect. IE	0.5 acid melted elect. IE	30	No failure	30	No failure	Apr. 19	Do.
97-C	Feb. 23	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	28	No failure	27	No failure	Apr. 19	No sulfide staining, traces of peeling at side seam only.
98-C	Feb. 23	1.25 OPM IE	Enameled bonderized	37	No failure	36	No failure	Apr. 19	No sulfide staining, slight traces of enamel peeling.
99-C	Feb. 23	1.25 OPM plain	1.25 OPM plain	48	No failure	48	No failure	Apr. 19	Light sulfide spots. Cans could be used.
100-C	Feb. 23	0.5 acid melted elect. plain	0.5 acid melted elect. plain	48	273	48	342	Apr. 19	Almost as good as 99-C for first 6 months.
101-C	Feb. 23	0.5 alk. melted elect. plain	0.5 alk. melted elect. plain	48	No failure	48	No failure	Apr. 19	Sulfide staining moderate at end of trial. Questionable, but not failure.
102-C	Feb. 23	1.25 OPM plain	Enameled bonderized	48	No failure	48	No failure	Apr. 19	Traces of sulfide stains on body, traces of peeling on ends.

Can size: No. 1 standard (211 x 400). Process: 14 min. at 250° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
99-A	Feb. 24	1.25 OPM plain	1.25 OPM plain	50	No failure	50	No failure	Apr. 25	Light sulfide staining at end of test period. Cans could be used.
100-A	Feb. 24	0.5 acid melted elect. plain	0.5 acid melted elect. plain	50	233	50	233	Apr. 25	Moderate but noticeable sulfide staining.
101-A	Feb. 24	0.5 alk. melted elect. plain	0.5 alk. melted elect. plain	50	233	50	233	Apr. 25	Not total commercial failure, but customers would object.
102-A	Feb. 24	1.25 OPM IE	Enameled bonderized	50	No failure	50	No failure	Apr. 25	Slight sulfide staining.

Oysters, Pacific: Table 16. The oysters were packed in the regular series of inside-enameled cans, supplied by each of two can companies. All plates were considered satisfactory. Unlike the clams, the packs of oysters showed no sulfide staining beneath the enamel. The insides of the cans were perfectly bright, with only traces of peeling.

Can size: No. 1 tall (301 x 411). Process: 35 min. at 240° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
102-A	Apr. 7	1.25 OPM IE	1.25 OPM IE	22	No failure	22	No failure	July 22	No sulfide staining, light peeling of enamel on body, side seam and ends.
103-A	Apr. 7	0.5 acid melted elect. IE	0.5 acid melted elect. IE	24	No failure	24	No failure	July 22	No sulfide staining, traces of enamel peeling on side seam.
104-A	Apr. 7	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	20	No failure	19	No failure	July 22	Do.
105-A	Apr. 7	1.25 OPM IE	Enameled bonderized	22	No failure	22	No failure	July 22	No sulfide staining; trace of enamel peeling on body, side seam and ends.
102-C	May 7	1.25 OPM IE	1.25 OPM IE	12	No failure	12	No failure	July 25	No sulfide staining, trace of enamel peeling on side seam.
103-C	May 7	0.5 acid melted elect. IE	0.5 acid melted elect. IE	12	No failure	12	No failure	July 25	Do.
104-C	May 7	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	12	No failure	12	No failure	July 25	Do.
105-C	May 7	1.25 OPM IE	Enameled bonderized	12	No failure	12	No failure	July 25	No sulfide staining, trace of peeling of enamel on side seam and ends.

Roe, "Deep Sea" fish: Table 17. The inside-enameled cans made from the 1.25 OPM and the 0.5 acid melted electrolytic plates were satisfactory. While neither of the packs in the cans of 1.25 OPM plate with bonderized ends could be called a commercial failure, there was a certain amount of peeling of the bonderized ends. The other plates were not satisfactory.

Can size: No. 300 (300 x 407). Process: 80 min. at 240° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1942							1944	
133-C	Nov. 21	1.25 OPM IE	1.25 OPM IE	45	No failure	45	No failure	Apr. 11	Showed light sulfide staining under enamel at end of one year, moderate when discontinued.
134-C	Nov. 21	0.5 acid melted elect. plate IE	0.5 acid bath melted elect. plate IE	45	No failure	45	No failure	Apr. 11	Moderate sulfide stain at end of year, no peeling.
135-C	Nov. 21	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	45	228	45	228	Apr. 11	Peeling of enamel; general condition of can questionable.
136-C	Nov. 21	1.25 OPM IE	Enameled bonderized	45	No failure	45	No failure	Apr. 11	Light peeling on ends after 8 months.
133-A	Nov. 24	1.25 OPM plain	1.25 OPM plain	36	No failure	36	No failure	Apr. 12	Moderate sulfide staining and detinning at end of 6 months, did not increase.
134-A	Nov. 24	0.5 acid melted elect. plain	0.5 acid melted elect. plain	36	360	36	360	Apr. 12	
135-A	Nov. 24	0.5 alk. melted elect. plain	0.5 alk. melted elect. plain	36	360	36	360	Apr. 12	
136-A	Nov. 24	1.25 OPM IE	Enameled bonderized	48	No failure	48	No failure	Apr. 12	Showed moderate peeling of ends after one year, general condition questionable.

Roe, river herring: Table 18. The roe was packed at the same time as the herring. This series likewise included one plain plate, namely, 1.25 OPM. Though the cans showed little or no sulfide staining all cans became swells. This is thought to be due to the process and the condition of the raw material.

Can size: No. 300 (300 x 407). Process: 55 min. at 245° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
		Bodies	Ends						
	1943							1943	
134-A	May 28	1.25 OPM IE	1.25 OPM IE	24	216	24	216	Dec. 30	No sulfide staining, peeling of enamel moderate to light, but all cans swells.
134-C	May 28	1.25 OPM plain	1.25 OPM plain	24	216	24	216	Dec. 30	Sulfide staining light, corrosion light, but all cans swells.
135-A	May 28	0.5 acid melted elect. IE	0.5 acid melted elect. IE	24	216	24	216	Dec. 30	No sulfide staining, peeling of enamel light, but all cans swells.
136-A	May 28	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	24	216	24	216	Dec. 30	No sulfide staining, peeling of enamel severe, all cans swells.
137-A	May 28	1.25 OPM IE	Enameled bonderized	24	216	24	216	Dec. 30	Traces of sulfide staining, enamel peeling light to moderate. All cans swells.

Salmon, Chinook: Table 19. The Chinook salmon was packed in cans from the same batch of plate used for Dungeness crab. The cans showed some sulfide staining beneath the enamel, but in no case was the darkening sufficiently prominent to be readily noticed by the consumer. There was a little peeling of the enamel from the tinned surfaces, but not from the bonderized ends. All of the cans were considered satisfactory.

Can size: ½ flat (307 x 201.25). Process: 85 min. at 241° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
		Bodies	Ends						
	1943							1944	
23	May 6	1.25 OPM IE	1.25 OPM IE	12	No failure	12	No failure	July 25	Sulfide staining light, peeling of enamel from trace to light.
24	May 6	0.5 acid melted elect. IE	0.5 acid melted elect. IE	12	No failure	12	No failure	July 25	Moderate sulfide stain beneath enamel, enamel peeling light.
25	May 6	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	12	No failure	12	No failure	July 25	Do.
26	May 6	1.25 OPM IE	Enameled bonderized	12	No failure	12	No failure	July 25	Sulfide stain beneath enamel light, peeling of enamel on side seam light, none on ends.

Salmon, pink: Table 20. The pink salmon was packed in inside-enameled cans only. There was some sulfide staining beneath the enamel. The enamel peeled from all of the tin surfaces but not from the bonderized ends. This extensive peeling appeared first at the unstriped side seams.

Can size: No. 1 tall (301 x 411). Process: 95 min. at 242° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
		Bodies	Ends						
	1943							1944	
8-A	Sept. 10	1.25 OPM IE	1.25 OPM IE	24	No failure	24	No failure	Oct. 13	Sulfide stain beneath enamel moderate. Complete peeling of enamel on body and side seam.
9-A	Sept. 10	0.5 acid melted elect. IE	0.5 acid melted elect. IE	24	300	24	378	Oct. 13	Sulfide stain beneath enamel moderate, complete enamel peeling on side seam and body.
10-A	Sept. 10	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	24	300	24	378	Oct. 13	Sulfide stain moderate. Complete peeling of enamel on body and side seam from first examination.
11-A	Sept. 10	1.25 OPM IE	Enameled bonderized	24	No failure	24	No failure	Oct. 13	Complete peeling of enamel on body and side seam, no peeling of bonderized ends.

Sardine, California: Table 21. Two packs were made of California sardines, one pack was natural style, in brine, and the other in tomato sauce. In both instances 1.25 OPM plain and 0.5 acid melted electrolytic inside-enameled plate cans were used. Both packs of the 0.5 acid melted electrolytic inside-enameled plate were satisfactory, but the packs using 1.25 OPM plain plates were failures.

Can size: 1 lb. oval. Process: 75 min. at 240° F.

Code	Date Packed	Plate Bodies	Plate Ends	Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1943							1944	
35*	Feb. 11	1.25 OPM, plain	1.25 OPM, plain	24	209	24	245	July 19	Commercial failure
36*	Feb. 11	0.5 acid melted elect. IE	0.5 acid melted elect. IE	24	No failure	24	No failure	July 19	Sulfide staining moderate, enamel peeling light.
39**	Feb. 11	1.25 OPM, IE	1.25 OPM, IE	24	126	24	175	July 19	Held several months after commercial failure until all cans became swells.
40**	Feb. 11	0.5 acid melted elect. IE	0.5 acid melted elect. IE	24	No failure	24	No failure	July 19	Sulfide staining moderate, enamel peeling moderate, all cans swells.

* Packed in brine. ** Packed in tomato sauce.

Sardines, Maine, in mustard: Table 22. This series likewise included only the 0.5 acid melted electrolytic cans, the 1.25 OPM cans and the bonderized cans, all inside-enameled. Only the first two were satisfactory. The bonderized cans showed little sulfide staining at the close of the storage period; but, although there were no swells, there was considerable corrosion accompanied by complete peeling of the enamel.

Can size: ¼ oil. Process: 60 min. at 223° F.

Code	Date Packed	Plate Bodies	Plate Ends	Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1943							1944	
27	June 10	1.25 OPM, IE	1.25 OPM, IE	50	No failure	50	No failure	July 18	Sulfide staining light, enamel peeling on body and ends light.
32	June 10	0.5 acid melted elect. IE	0.5 acid melted elect. IE	50	No failure	50	No failure	July 18	Trace of sulfide staining, enamel peeling light on body and ends.
33	June 10	Enameled bonderized	Enameled bonderized	50	403	50	403	July 18	Severe corrosion; complete peeling of enamel.

Note: No alkaline elect. plate. Failed in manufacture.

Sardines, Maine, in oil: Table 23. The same three plates were tried as for the Maine sardines in mustard. All of the types tested were satisfactory, but some difficulty was experienced in sealing the bonderized tops.

Can size: ¼ oil. Process 60 min. at 223° F.

Code	Date Packed	Plate Bodies	Plate Ends	Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1943							1944	
31	June 10	1.25 OPM, IE	1.25 OPM, IE	50	No failure	50	No failure	July 14	Sulfide staining trace, enamel peeling on body light.
28	June 10	0.5 acid melted elect. IE	0.5 acid melted elect. IE	50	No failure	50	No failure	July 14	No sulfide staining, trace only of enamel peeling.
29	June 10	Enameled bonderized	Enameled bonderized	50	No failure	50	No failure	July 14	Sulfide staining light, enamel peeling body and ends light to trace.

Note: No alkaline electrolytic sardine cans; all attempts failed in manufacture.

Shad: Table 24. This product was packed in plain cans only. The electrolytic plates were commercial failures. While the 1.25 OPM plate did not fail, the amount of sulfide blackening and detinning was sufficient to make the use of this plate undesirable. The bonderized ends showed only light peeling. The need for inside-enameled plates is clearly indicated.

Can size: No. 1 tall (301 x 411). Process: 95 min. at 241° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
75-A	June 24	1.25 OPM plain	1.25 OPM plain	24	No failure	24	No failure	Sept. 20	Sulfide staining, corrosion and detinning all moderate.
76-A	June 24	0.5 acid melted elect.	0.5 alk. melted elect.	12	447	12	447	Sept. 20	Sulfide staining severe, shad had tinny taste and odor.
77-A	June 24	0.5 alk. melted elect.	0.5 alk. melted elect.	12	447	12	447	Sept. 20	Sulfide staining severe, cans swells.
78-A	June 24	1.25 OPM plain	Enameled bonderized	12	No failure	12	No failure	Sept. 20	Sulfide staining and detinning of body moderate, light peeling of bonderized ends.

Shrimp, dry-pack: Table 25. All packs of this series were satisfactory. The bonderized ends showed light peeling. The acid melted plate was at least as good as the 1.25 OPM plate. Though these packs were made at the same time as the wet-pack shrimp, using the same lots of cans and raw materials the cans appeared much better with the dry-pack shrimp, being free from sulfide staining, or showing only a trace of such discoloration.

Can size: No. 1 Standard (211 x 400). Process: 66 minutes at 240° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
118-C	Feb. 22	1.25 OPM, IE	1.25 OPM, IE	36	No failure	35	No failure	Apr. 19	Traces only of sulfide staining and enamel peeling.
119-C	Feb. 22	0.5 acid melted elect. IE	0.5 acid melted elect. IE	24	No failure	24	No failure	Apr. 19	No sulfide staining, only slight traces of peeling.
120-C	Feb. 22	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	37	No failure	36	No failure	Apr. 19	Sulfide staining trace to light, enamel peeling trace.
121-C	Feb. 22	1.25 OPM, IE	Enameled bonderized	37	No failure	36	No failure	Apr. 19	Sulfide staining trace only. Enamel peeling light on body and ends.

Same cans and shrimp as in wet pack, but dry pack shows up much better.

Shrimp, wet-pack: Table 26. The alkaline melted electrolytic plate with inside enamel was considered a commercial failure because both sulfide staining and enamel peeling were severe. The other plates also showed moderate staining under the enamel, though not to a degree which might cause a consumer to reject the cans. With these plates there was little peeling of the enamel, even at the end of the test period.

Can size: No. 1 Standard (211 x 400). Process: 13 min. at 250° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
114-C	Feb. 22	1.25 OPM, IE	1.25 OPM, IE	31	No failure	31	No failure	Apr. 19	Sulfide staining under enamel moderate, enamel peeling light to moderate.
115-C	Feb. 22	0.5 acid melted elect. IE	0.5 acid melted elect. IE	31	No failure	30	No failure	Apr. 19	Sulfide staining under enamel moderate, traces only of enamel peeling.
116-C	Feb. 22	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	27	273	27	309	Apr. 19	Sulfide staining and enamel peeling severe.
117-C	Feb. 22	1.25 OPM,	Enameled bonderized	37	No failure	36	No failure	Apr. 19	Sulfide staining moderate, enamel peeling traces to light.

Tuna, bluefin: Table 27. This series was packed in both plain and inside-enameled cans. The results roughly parallel those obtained in the other tuna packs. The plain 1.25 OPM plate was stained to some extent, but was usable. Both electrolytic plates, plain inside, were commercial failures, with much sulfide staining and corrosion and with most of the cans becoming hydrogen swells before the packs were discarded. The alkaline electrolytic plate, inside-enameled, did not show much staining, but there was considerable peeling. The 1.25 OPM and 0.5 acid electrolytic plates, inside-enameled, showed no sulfide stain and only a trace of peeling of the enamel. There is every indication that these two latter plates are completely satisfactory. All of the plain plates seemed to become failures at about the same time. The bonderized ends showed considerable peeling.

Can size: 1/2 tuna (307 x 113). Process: 75 minutes at 242° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
55-C 1853	June 15	1.25 OPM, IE	1.25 OPM, IE	16	No failure	16	No failure	Sept. 20	No sulfide staining, enamel peeling light.
55-C-1 1854	June 15	1.25 OPM, plain	1.25 OPM plain	8	No failure	8	No failure	Sept. 20	Sulfide staining and corrosion moderate.
56-C 1855	June 15	0.5 acid melted elect. IE	0.5 acid melted elect. IE	16	No failure	16	No failure	Sept. 20	No sulfide staining, enamel peeling trace.
56-C-1 1856	June 15	0.5 acid melted plain	0.5 acid melted plain	8	427	8	427	Sept. 20	Severe sulfide staining and corrosion, 75% hydrogen swells.
57-C 1857	June 15	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	16	No failure	16	No failure	Sept. 20	Sulfide staining trace; enamel peeling from moderate to severe.
57-C-1 1858	June 15	0.5 alk. melted elect. plain	0.5 alk. melted elect. plain	8	427	8	427	Sept. 20	Severe sulfide staining and corrosion, all cans hydrogen swells 9-20.
58-C 1859	June 15	1.25 OPM, IE	Enameled bonderized	16	No failure	16	No failure	Sept. 20	Sulfide staining light, enamel peeling trace on body and side seam, moderate on ends.
58-C-1 1860	June 15	1.25 OPM plain	Enameled bonderized	8	427	8	427	Sept. 20	Sulfide staining severe, enamel peeling on ends severe.

Note: These cans were made by a different manufacturer than those listed in Table 28.

Tuna, bluefin: Table 28. This series was packed only in three plain plates and in plain 1.25 OPM bodies with inside-enameled bonderized ends. These cans were made by a different company than those in the preceding series. Commercial failure resulted in a shorter time with the electrolytic plates of this company, but the bonderized ends in these packs showed only traces of peeling.

Can size: 1/2 tuna (307 x 113). Process: 75 minutes at 242° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
55-A	June 16	1.25 OPM plain	1.25 OPM plain	12	No failure	12	No failure	Sept. 20	Sulfide staining and detinning moderate.
56-A	June 16	0.5 acid melted elect. plain	0.5 acid melted elect. plain	12	191	12	272	Sept. 20	Sulfide staining and detinning severe.
57-A	June 16	0.5 alk. melted elect. plain	0.5 alk. melted elect. plain	12	191	12	272	Sept. 20	Do.
58-A	June 16	1.25 OPM plain	Enameled bonderized	12	No failure	12	No failure	Sept. 20	Body shows severe sulfide staining and detinning; bonderized ends show trace only of peeling, in good condition.

Note: These cans were made by a different manufacturer than those listed in Table 27.

Tuna, striped: Table 29. This species was packed in a complete series of both plain and inside-enameled cans. The results correspond to those obtained with yellowfin tuna, except that results were apparent after a somewhat shorter time of incubation.

Can size: 1/2 tuna (307 x 113). Process: 75 min. at 242° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
1853	Feb. 13	1.25 OPM, IE	1.25 OPM, IE	16	No failure	16	No failure	July 20	Sulfide staining trace, enamel peeling moderate
1854	Feb. 13	1.25 OPM, plain	1.25 OPM, plain	8	247	8	362	July 20	Dark purple sulfide stain, some corrosion
1855	Feb. 13	0.5 acid melted elect. IE	0.5 acid melted elect. IE	16	No failure	16	No failure	July 20	Sulfide staining trace, enamel peeling light on body, moderate on ends.
1856	Feb. 13	0.5 acid melted elect. plain	0.5 acid melted elect. plain	8	210	8	249	July 20	All cans remaining were swells by July 20, 1944.
1857	Feb. 13	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	16	No failure	16	No failure	July 20	Sulfide staining trace, enamel peeling moderate on body and ends.
1858	Feb. 13	0.5 alk. melted elect. plain	0.5 alk. melted elect. plain	8	210	8	249	July 20	All cans remaining were swells by July 20, 1944.
1859	Feb. 13	1.25 OPM IE	Enameled	16	No failure	16	No failure	July 20	Severe peeling of ends.
1860	Feb. 13	1.25 OPM plain	Enameled bonderized	8	210	8	249	July 20	Enamel peeling on ends somewhat worse than preceding.

Tuna, striped: Table 30. Only inside-enameled cans supplied by the second can company were used in this series. The alkaline plate was a failure. The bonderized ends showed some peeling.

Can size: 1/2 tuna (307 x 113). Process: 75 min. at 242° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
63-A	Feb. 15	1.25 OPM, IE	1.25 OPM, IE	24	No failure	24	No failure	July 21	Trace only of sulfide staining, light peeling of enamel on body and end seams, heavy on side seams.
64-A	Feb. 15	0.5 acid melted IE	0.5 acid melted IE	24	No failure	24	No failure	July 21	Do.
65-A	Feb. 15	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	24	175	24	175	July 21	Sulfide staining moderate, complete peeling of enamel.
66-A	Feb. 15	1.25 OPM, IE	Enameled bonderized system #1	24	No failure	24	No failure	July 21	No sulfide staining; light peeling of enamel on side seam.
66-A-1	Feb. 15	1.25 OPM, IE	Enameled bonderized system #2	24	No failure	24	No failure	July 21	No sulfide staining, light peeling of enamel on body, side seams, and ends.

Tuna, yellowfin: Table 31. This series included the four variants in two complete series, inside-enameled and plain. None of the inside-enameled plates could be considered a failure, but the 0.5 acid melted electrolytic plate, inside-enameled, was the most satisfactory. The bonderized ends of both types of 1.25 OPM plate cans, plain and inside-enameled, showed a good deal of peeling. All of the plain plates were commercial failures, though the cans made with 1.25 OPM plate bodies and ends were in storage for 13 months at 90° F., before they were classed as failures.

Can size: 1/2 tuna (307 x 113). Process: 75 min. at 242° F.

Code	Date packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
1853	Feb. 13	1.25 OPM, IE	1.25 OPM, IE	16	No failure	16	No failure	July 20	Traces of sulfide staining, enamel peeling light to moderate
1854	Feb. 13	1.25 OPM plain	1.25 OPM plain	8	446	8	No failure	July 20	Sulfide stain and corrosion severe on incubated sample, moderate on 70° sample.
1855	Feb. 13	0.5 acid melted elect. IE	0.5 acid melted elect. IE	16	No failure	16	No failure	July 20	Sulfide stain and enamel peeling trace.
1856	Feb. 13	0.5 acid melted elect. plain	0.5 acid melted elect. plain	8	280	8	362	July 20	Remaining cans became swells 7-20-44.
1857	Feb. 13	0.5 alk. melted elect. IE	0.5 alk. melted elect. IE	16	No failure	16	No failure	July 20	Sulfide staining trace, enamel peeling moderate.
1858	Feb. 13	0.5 alk. melted elect. plain	0.5 alk. melted elect. plain	8	247	8	362	July 20	Remaining cans became swells 7-20-44.
1859	Feb. 13	1.25 OPM, IE	Enameled bonderized	16	No failure	16	No failure	July 20	Enamel peeling of ends severe 7-20-44.
1860	Feb. 13	1.25 OPM, plain	Enameled bonderized	8	247	8	362	July 20	Enamel peeling on ends very severe.

Tuna, yellowfin: Table 32. This series was packed in cans manufactured by a second can company. It included the four variants, inside-enameled only, with two different types of bonderized ends, or five packs in all. The alkaline melted electrolytic plate failed in a comparatively short time. Neither type of bonderized end showed peeling.

Can size: 1/2 tuna (307 x 113). Process: 75 min. at 242° F.

Code	Date packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1943							1944	
59-A	Feb. 15	1.25 OPM, IE	1.25 OPM, IE	24	No failure	20	No failure	July 21	Sulfide staining trace, enamel peeling only at side seam.
60-A	Feb. 15	0.5 acid melted elect. IE	0.5 acid melted elect. IE	24	No failure	24	No failure	July 21	Sulfide staining light, enamel peeling severe at side seam, light at ends.
61-A	Feb. 15	0.5 alk. melted elect.	0.5 alk.	24	126	24	126	July 21	Light sulfide staining, enamel peeling severe by 9-3-43.
62-A	Feb. 15	1.25 OPM IE	Enameled bonderized, System #1	24	No failure	24	No failure	July 21	No sulfide staining, enamel peeling only at side seam.
62-A-1	Feb. 15	1.25 OPM IE	Enameled bonderized, System #2	24	No failure	24	No failure	July 21	Do.

CONCLUSIONS

1. The cans made from 0.5 acid melted electrolytic plate, inside-enameled, are satisfactory for all of the canned fishery products tested.

2. The cans made from 0.5 alkaline melted electrolytic plate, inside-enameled, were not satisfactory for many fishery products because of extensive peeling of the enamel. Good results were secured however, with oysters, razor clams, and crabs.

Note: Poor enamel adhesion was characteristic of alkaline melted electrolytic plate at the time these packs were made. Considerable improvement has taken place since 1942, and this plate is now used interchangeably with the acid melted and halogen types.

3. Cans made with bonderized ends and 1.25 OPM plate bodies seem satisfactory for nearly all canned fishery products. Possible exceptions are Manhattan chowder, pilchards in tomato sauce, and sardines in mustard.

4. Deterioration appeared in the bonderized ends when plain bodies were used. It did not occur in parallel packs when the bodies were inside-enameled.

5. When the raw material was in poor condition, deterioration appeared in the substitute plates, whereas the same containers are used successfully with the same products when the raw material is fresh.

6. Cans made of 1.25 OPM plate with plain inside, and 0.5 acid melted electrolytic plate with plain inside, can probably be used in packing Atlantic oysters.

7. Wet-pack shrimp produce much more sulfide staining under the enamel than dry-pack shrimp.

8. Hard clams are much more apt to produce sulfide staining under the enamel than do soft clams.

9. Plain cans of 0.5 acid or alkaline melted electrolytic plate are unsatisfactory with the single exception noted in conclusion 6. Of the packs tested, the 1.25 OPM plate, plain bodies and ends, is also unsatisfactory.

10. Bluefin tuna, Boston mackerel, California mackerel, fish flakes, hard clams, and Maine sea herring are more affected by high temperature storage than other canned fishery products.

PART II

In 1943 it was decided to test three additional plate variations which had not been included in the earlier project reported in Part I. At the same time a few of the previous packs were repeated in order to check the validity of certain of our earlier conclusions. This second series of packs was prepared in the canning season of 1943-44. The methods of storage and examination were similar to those described in Part I.

Only the results obtained in the supplementary program of 1943-44 are presented herewith. The substitute container program itself is not discussed in any detail, since the data given are only supplementary to Part I.

Explanation of Abbreviations and Definitions of Terms Not Used in Part I

0.25 acid elect. - is an electrolytic tin plate, 0.25 lb. per base box, acid bath.

0.125 acid elect. - is an electrolytic tin plate, 0.125 lb. per base box, acid bath.

B.S.E. - means both sides enameled.

Summary of Observations

Albacore: Table 1. The albacore was packed in the two plate variations not previously tested, namely, 0.25 acid melted electrolytic plate, both sides enameled, and 0.5 acid melted electrolytic bodies with bonderized ends. When these packs were discarded both types were in very good condition with very light sulfide staining and with light enamel peeling on the side seam only. Both plates appear satisfactory for packing this product.

Can size: 1/2 tuna (307 x 113). Process: 75 min. at 242° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1944							1945	
219	July 25	0.25 acid melt. elect. B.S.E.	0.25 acid melt elect. B.S.E.	24	No failure	24	No failure	July 18	Sulfide stain light on bodies and ends. Side seam only showed light peeling of enamel.
220	July 25	0.5 acid melt. elect.	Enameled bonderized	24	No failure	24	No failure	July 18	Sulfide stain traces on body only. Moderate enamel peeling on side seam only.

Clams, hard, Atlantic: Table 2. This product was packed only in the two new plate variations. The insides of the cans showed moderate sulfide staining at the first examination. The bonderized ends were not affected. Both types of cans also showed traces of enamel peeling on the body, side seam and ends at the first examination. Neither the sulfide staining nor the enamel peeling progressed further during the storage period. The cans were in practically the same condition when discarded as at the first examination. Both types seem to be satisfactory.

Can size: No. 1 standard (211 x 400). Process: 25 min. at 240° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1944							1945	
199	May 6	0.25 acid melt. elect. B.S.E.	0.25 acid melt. elect. B.S.E.	24	No failure	24	No failure	July 12	Sulfide stain moderate on body and ends. Enamel peeling light on body, side seam and ends.
200	May 6	0.5 acid melt elect. IE	Enameled bonderized	24	No failure	24	No failure	July 12	Sulfide stain severe on body, none on ends. Enamel peeling traces on body, side seam, and ends.

Clams, soft: Table 3. The soft clams were also packed only in the two plate variations for 1943-44. The bonderized ends did not show sulfide staining or corrosion, but did develop light peeling during the storage period. The 0.5 plate bodies, and 0.25 bodies and ends showed noticeable, but moderate, sulfide stain at the first examination. There was no increase in deterioration at subsequent examinations. Both types are regarded as satisfactory.

Can size: No. 1 standard (211 x 400). Process: 20 minutes at 240° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1944							1945	
172	Jan. 21	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	25	No failure	25	No failure	June 27	Sulfide staining moderate on body and ends. Enamel peeling light on body and ends, trace on side seam.
173	Jan. 21	0.5 acid melt. elect. IE	Enameled bonderized	25	No failure	25	No failure	June 27	Sulfide staining severe on body, none on ends. Enamel peeling light on body, side seam and ends.

Clam chowder, Manhattan style: Table 4. Both the cans of 0.25 acid electrolytic plate and those having 0.5 acid electrolytic bodies with bonderized ends are regarded as satisfactory. Practically no changes were noted in thirteen months of storage at 90° F.

Can size: No. 1 standard (211 x 400). Process: 75 min. at 240° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1944							1945	
205	May 24	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	24	No failure	24	No failure	July 16	No sulfide stain. Enamel peeling light on side seam and ends.
206	May 24	0.5 acid melt. elect.	Enameled bonderized	24	No failure	24	No failure	July 16	No sulfide stain. Enamel peeling light on side seam and trace on ends.

Clam chowder, New England style: Table 5. The 0.25 acid electrolytic plate did not show much sulfide stain, but the enamel peeling was sufficiently pronounced to make use of this plate questionable. This may be due to the chowder formula. A different enamel might be completely satisfactory.

Can size: No. 1 standard (211 x 400). Process: 60 min. at 240° F.

Code	Date Packed	Plate		Storage at 90° F.		Storage at 70° F.		Date pack discarded	Remarks
		Bodies	Ends	Number of cans stored	Days to commercial failure	Number of cans stored	Days to commercial failure		
	1944							1945	
170	Jan. 21	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	25	No failure	25	No failure	June 27	Sulfide staining and corrosion light on body and ends. Peeling moderate on body, severe on side seam, light on ends.
171	Jan. 21	0.5 acid melt. elect. IE	Enameled bonderized	25	No failure	25	No failure	June 27	Sulfide staining light on body, absent on ends. Enamel peeling light on body, severe on side seam, trace on ends.

Crab, Dungeness: Table 6. The cans packed were of 0.5 acid electrolytic plate with bonderized ends and of 0.25 acid electrolytic plate throughout. Each type of can was packed in two series using two series using two different enamels. Some difference was noted between the two enamels, but either would be suitable. The can maker's code No. 6056, was considered more satisfactory for the 0.25 electrolytic plate, with code No. 6057 preferred for the 0.5 electrolytic plate bodies with bonderized ends.

Can size: 1/2 flat (307 x 201.25). Process: 70 minutes at 230° F.

Code	Date Packed	Plate Bodies	Plate Ends	Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1944							1945	
210* (6054)	Apr. 27	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	24	No failure	24	No failure	July 16	Sulfide stain moderate on body, trace on ends. Light enamel peeling on side seam only.
(6056)		Do.	Do.	24	No failure	24	No failure	July 16	No sulfide stain. Light enamel peeling on side seam only.
211* (6055)	Apr. 27	0.5 acid melt. elect. IE	Enameled bonderized	24	No failure	24	No failure	July 16	Sulfide stain moderate on body, none on ends. Light enamel peeling on side seam only.
(6057)		Do.	Do.	24	No failure	24	No failure	July 16	Sulfide stain trace on body only. Enamel peeling light on body and ends.

* Two different types of enamel were used. Codes (6054) and (6055) had one type of inside enamel. Codes (6056) and (6057) had another type.

Fish chowder, New England (haddock): Table 7. The results in this series are similar to those obtained with the New England clam chowder packs. There was practically no change in the condition of the plates after the first examination, but enamel peeling was classed as moderate throughout the storage period. The cans were from the same lot used for the New England clam chowder packs.

Can size: No. 1 standard (211 x 400). Process: 75 minutes at 230° F.

Code	Date Packed	Plate Bodies	Plate Ends	Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1944							1945	
177	Jan. 25	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	25	No failure	25	No failure	June 28	Sulfide stain light on bodies and ends; light corrosion on bodies and ends. Enamel peeling moderate on bodies, side seam and ends.
178	Jan. 25	0.5 acid melt. elect. IE	Enameled bonderized	25	No failure	25	No failure	June 28	Sulfide stain moderate on bodies and ends. Enamel peeling moderate on bodies, side seam and ends.

Fish flakes: Table 8. This series included the new plates plus two lots repeated from the previous year, namely, 1.25 OPM plate, plain and inside-enameled. The results obtained confirmed previous conclusions. The 1.25 OPM plain cans were failures at the first examination. The 1.25 OPM inside-enameled cans showed some sulfide stain and enamel peeling but are considered satisfactory. The 0.25 OPM plate cans had a better inside appearance than the 1.25 OPM inside-enameled cans with less enamel peeling. The 0.5 electrolytic plate bodies with bonderized ends showed no progressive deterioration. Both of the last two experimental types are considered satisfactory.

Can size: No. 300 (300 x 407). Process: 80 minutes at 240° F.

Code	Date Packed	Plate Bodies	Plate Ends	Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1944							1945	
179	Jan. 26	1.25 OPM plain	1.25 OPM plain	25	184	25	277	June 28	Commercial failure may have occurred earlier. Examination delayed by field work.
180	Jan. 26	1.25 OPM IE	1.25 OPM IE	25	No failure	25	No failure	June 28	Sulfide stain moderate, body and ends. Enamel peeling moderate, body, side seam, and ends.
181	Jan. 26	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	25	No failure	25	No failure	July 5	Sulfide stain light on body, moderate on ends. Enamel peeling light, body, side seam, and ends.
182	Jan. 26	0.5 acid melt. elect. IE	Enameled bonderized	25	No failure	25	No failure	July 5	Sulfide stain moderate on body, none on ends. Enamel peeling light on body and side seam, none on ends.

Herring, river: Table 9. Both the 0.25 electrolytic plate, and the cans with 0.5 electrolytic bodies and bonderized ends showed no sulfide stains, and only light enamel peeling. Both types seem satisfactory. The fish was in good condition when packed. Cans packed with stale river herring in the preceding year showed extensive enamel peeling.

Can size: No. 2 (307 x 409). Process: 60 minutes at 250° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
		Bodies	Ends						
	1944							1945	
201	May 9	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	24	No failure	24	No failure	July 12	No sulfide stain on bodies, trace on ends. Enamel peeling light on side seams and ends, trace on bodies.
202	May 9	0.5 acid melt. elect. IE	Enameled bonderized	24	No failure	24	No failure	July 12	No sulfide stain on ends, trace on bodies. Enamel peeling light on side seams and ends, trace on bodies.

Herring, sea: Table 10. The sea herring packs were all satisfactory. The reports showed little change in condition from the time the packs were placed in incubation until they were discarded. There were only traces of sulfide stain, and little enamel peeling.

Can size: No. 300 (300 x 407). Process: 75 minutes at 240° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
		Bodies	Ends						
	1944							1945	
216	Aug. 9	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	24	No failure	24	No failure	July 18	Sulfide staining light on body, none on ends. Enamel peeling light on bodies and side seams; trace on ends.
217	Aug. 9	0.5 acid melt. elect. IE	0.5 acid melt. elect. IE	24	No failure	24	No failure	July 18	Sulfide stain; trace on bodies and ends. Enamel peeling; body none, side seam moderate, ends trace.
218	Aug. 9	0.5 acid melt. elect. IE	Enameled bonderized	24	No failure	24	No failure	July 18	Sulfide stain; body trace; ends none. Enamel peeling; side seam only, moderate.

Mackerel, Boston: Table 11. The 1.25 OPM plain and inside-enameled packs were repeated to check on results obtained with the 1942-43 packs. The previous conclusion was confirmed that the 1.25 OPM plain cans are not satisfactory. The use of the 0.25 electrolytic plate is not recommended although there was little sulfide staining. Twenty percent of the incubated cans were swells, and the ends showed almost complete peeling of enamel. The cans with 0.5 electrolytic bodies and bonderized ends are considered satisfactory.

Can size: No. 300 (300 x 407). Process: 55 minutes at 240° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
		Bodies	Ends						
	1944								
183	Jan. 26	1.25 OPM plain	1.25 OPM plain	25	277	25	323	Dec. 15, 1944	Incubated cans showed no vacuum at first examination. 70% of cans swells 12-15-44.
184	Jan. 26	1.25 OPM IE	1.25 OPM IE	25	No failure	25	No failure	July 5, 1945	Sulfide stain light on body and ends. Enamel peeling light on body and ends; severe on side seam.
185	Jan. 26	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	25	No failure	25	No failure	July 5, 1945	Sulfide stain light on body, moderate on ends. Enamel peeling light on body, severe on side seam, commercial failure on ends.
186	Jan. 26	0.5 acid melt. elect. IE	Enameled bonderized	25	No failure	25	No failure	July 5, 1945	Sulfide stain light on body, none on ends. Enamel peeling light on body, severe on side seam, none on ends.

Mackerel, California: Table 12. The 0.25 electrolytic plate and the 0.5 electrolytic bodies with bonderized ends showed little deterioration under storage. All cans showed a complete loss of vacuum after 10 months of storage, however. Both types are regarded as satisfactory.

Can size: No. 300 (300 x 407). Process: 75 minutes at 250° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1943	Bodies	Ends					1945	
191	Dec. 15	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	24	No failure	24	No failure	July 5	Sulfide stain light on body and ends. Enamel peeling light on side seam, trace on body and ends.
192	Dec. 15	0.5 acid melt. elect. IE	Enameled bonderized	24	No failure	24	No failure	July 5	Sulfide stain moderate on body; none on ends. Enamel peeling moderate on body; severe on side seam; trace on ends.

Mussels: Table 13. The cans containing mussels showed about the same degree of sulfide staining under the enamel as those containing hard clams, that is, the stains covered the inside almost completely. The enamel was only affected slightly, and the color was not so dark that a consumer would reject the can. Odor and flavor of the product are normal.

Can size: No. 1 standard (211 x 400). Process: 25 minutes at 240° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1944	Bodies	Ends					1945	
174	Jan. 22	0.5 acid melt. elect. IE	0.5 acid melt. elect. IE	25	No failure	25	No failure	June 28	Sulfide staining severe bodies and end. Enamel peeling trace, bodies, ends, and side seams.
175	Jan. 22	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	25	No failure	25	No failure	June 28	Sulfide stain moderate on bodies and ends. Enamel peeling trace on body, light on side seam and ends.
176	Jan. 22	0.5 acid melt. elect. IE	Enameled bonderized	25	No failure	25	No failure	June 28	Sulfide stain severe on body, none on ends. Enamel peeling light on body and side seam, none on ends.

Oysters, Atlantic: Table 14. This series consisted of the two new types only. Both the 0.25 electrolytic plate and the 0.5 electrolytic bodies with bonderized ends are regarded as completely satisfactory. No sulfide stains were found in the examination of either type. The only apparent change during storage was the appearance of a trace of enamel peeling along the side seam.

Can size: No. 1 standard (211 x 400). Process: 14 minutes at 250° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1944	Bodies	Ends					1945	
197	Feb. 15	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	25	No failure	25	No failure	July 5	No sulfide stain on body or ends. Light enamel peeling on side seam only.
198	Feb. 15	0.5 acid melt. elect. IE	Enameled bonderized	25	No failure	25	No failure	July 5	Do.

Roe, river herring: Table 15. Both the 0.25 electrolytic plate and the 0.5 electrolytic bodies with bonderized ends showed only light enamel staining. No advance in deterioration was noted during storage. The plates are regarded as satisfactory.

Can size: No. 2 (307 x 409). Process: 60 minutes at 250° F.

Code	Date Packed	Plate: Bodies	Plate: Ends	Storage at 90° F.: Number of cans stored	Storage at 90° F.: Days to commercial failure	Storage at 70° F.: Number of cans stored	Storage at 70° F.: Days to commercial failure	Date pack discarded	Remarks
	1944							1945	
203	May 9	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	24	No failure	24	No failure	July 16	Sulfide stain light, bodies and ends. Enamel peeling moderate on bodies and ends, light on side seam.
204	May 9	0.5 acid melt. elect. IE	Enameled bonderized	24	No failure	24	No failure	July 16	Sulfide stain light on bodies, none on ends. Enamel peeling light on bodies, ends, and side seams.

Salmon, Chinook: Table 16. The Chinook salmon was packed in the same series of cans as the Dungeness crab. The results correspond to those obtained with the crab. Both types of enamels are satisfactory, but the can makers code 6056 is the better of the two enamels used for the 0.25 electrolytic cans, and code 6057 is the better of the two enamels used for the cans with 0.5 electrolytic bodies.

Can size: 1/2 flat (307 x 201.25). Process: 85 minutes at 240° F.

Code	Date Packed	Plate: Bodies	Plate: Ends	Storage at 90° F.: Number of cans stored	Storage at 90° F.: Days to commercial failure	Storage at 70° F.: Number of cans stored	Storage at 70° F.: Days to commercial failure	Date pack discarded	Remarks
	1944							1945	
212* (6054)	May 19	0.125 acid melt. elect. BSE	0.125 acid melt. elect. BSE	24	No failure	24	No failure	July 16	Sulfide stain light, body and ends. Enamel peeling, body none, side seam light, ends moderate.
(6056)		Do.	Do.	24	No failure	24	No failure	July 16	No sulfide stain body and ends. Light enamel peeling on side seam only.
213* (6055)	May 19	0.5 acid melt. elect. IE	Enameled bonderized	24	No failure	24	No failure	July 16	Moderate sulfide stain on body only. Light enamel peeling on side seam only.
(6057)		Do.	Do.	24	No failure	24	No failure	July 16	No sulfide stain. Enamel peeling, body light, side seam severe.

* Two different types of enamel were used. Codes (6054) and (6055) had one type of inside enamel. Codes (6056) and (6057) had another type.

Salmon, medium red (coho): Table 17. This species of salmon was packed in 1.25 OPM plate, plain and inside-enameled. The plain can deteriorated so that it would be noticeable to the consumer, but the container was not a commercial failure. The salmon was also packed in cans with 0.5 acid electrolytic bodies and bonderized ends, in two different enamel types. The first enamel type, can maker's code number 6051, showed up better than the second code number 6053. The first had no sulfide stains while the latter developed moderate sulfide stains on the body and enamel peeling of the ends. Salmon was also packed in cans of 0.125 electrolytic plate, both sides enameled in two types of enamel. Both enamels gave satisfactory results, but the can maker's code number 6050 is preferable as sulfide stain did not develop. Light to moderate sulfide stain developed with code number 6052. Enamel peeling of the ends varied from light to severe. The data on the examination sheets show a change from light to severe in the early examinations, but the cans opened for the last examinations showed only light enamel peeling.

Can size: 1 lb. tall (301 x 411). Process: 90 minutes at 240° F.

Code*	Date Packed	Plate: Bodies	Plate: Ends	Storage at 90° F.: Number of cans stored	Storage at 90° F.: Days to commercial failure	Storage at 70° F.: Number of cans stored	Storage at 70° F.: Days to commercial failure	Date pack discarded	Remarks
	1944							1945	
221 (6048)	Aug. 17	1.25 OPM plain	1.25 OPM plain	20	No failure	20	No failure	July 19	Sulfide stain moderate to severe on bodies and ends. Corrosion light.
222 (6049)	Aug. 17	1.25 OPM IE	1.25 OPM IE	20	No failure	20	No failure	July 19	Sulfide stain moderate, bodies and ends. Enamel peeling severe on bodies and side seam, moderate on ends.
223 (6050)	Aug. 17	0.125 acid melt. elect. BSE	0.125 acid melt. elect. BSE	24	No failure	24	No failure	July 19	No sulfide stain on body or ends. Light enamel peeling on side seam only.
224 (6051)	Aug. 17	0.5 acid melt. elect. IE	Enameled bonderized	20	No failure	20	No failure	July 19	No sulfide stain on body or ends. Light enamel peeling on side seam only.
225 (6052)	Aug. 17	0.125 acid melt. elect. BSE	0.125 acid melt. elect. BSE	24	No failure	24	No failure	July 19	Sulfide stain, body moderate, ends light. Enamel peeling light on body, side seam and ends.
226 (6053)	Aug. 17	0.5 acid melt. elect. IE	Enameled bonderized	20	No failure	20	No failure	July 19	Moderate sulfide stain on body only. Enamel peeling light on body and ends.

*Codes 223 (6050) and 224 (6051) had one type of enamel. Codes 225 (6052) and 226 (6053) had another type.

Sardines, California: Table 18. This pack consist d of two series; sardines in brine, and sardines in tomato sauce, packed in 0.125 electrolytic plate, both sides enameled, and 0.5 electrolytic bodies, inside-enameled, with bonderized tops. All the results were satisfactory. There was little change in the condition of the containers during the storage period.

Can size: 1 pound oval. Process: 75 minutes at 240° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1943	Bodies	Ends					1945	
187*	Dec. 15	0.125 acid melt. elect. BSE	0.125 acid melt. elect. BSE	24	No failure	24	No failure	July 5	Sulfide stain light, bodies and ends. Enamel peeling none. Natural (brine) pack.
188*	Dec. 15	0.5 acid melt. elect. IE	Enameled bonderized	24	No failure	24	No failure	July 5	Sulfide stain moderate on body, none on ends. Enamel peeling moderate on body, light on ends. Natural (brine) pack.
189**	Dec. 15	0.125 acid melt. elect. BSE	0.125 acid melt. elect. BSE	24	No failure	24	No failure	July 5	Sulfide stain moderate on body and ends. Enamel peeling none.
190**	Dec. 15	0.5 acid melt. elect. IE	Enameled bonderized	24	No failure	24	No failure	July 5	Sulfide stain light on body and ends. Enamel peeling light on body and ends.

* Packed in brine.
** Packed in tomato sauce.

Sardines, Maine, in mustard: Table 19. No difference was noted between the 0.125 electrolytic cans and the 0.25 electrolytic cans in the packing of mustard sardines. Both plates showed a moderate amount of deterioration at the first examination, but this did not increase during the storage period. The cans with bonderized ends were failures at the first examination.

Can size: 1/4 oil. Process: 150 minutes at 212° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1944	Bodies	Ends					1945	
167	Jan. 20	0.125 acid melt. elect. BSE	0.125 acid melt. elect. BSE	50	No failure	50	No failure	June 27	Sulfide staining moderate on body and ends. Corrosion light on body, trace on ends. Peeling moderate on body and ends.
168	Jan. 20	0.5 acid melt. elect. IE	Enameled bonderized	50	189	50	189	June 27	Sulfide staining moderate on body, none on ends. Complete peeling of enamel on ends.
169	Jan. 20	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	50	No failure	50	No failure	June 27	Sulfide staining moderate on body and ends. Corrosion light on body and ends. Enamel peeling moderate on body and ends.

Sardines, Maine, in oil: Table 20. The 0.125 electrolytic cans showed less sulfide stain than the 0.25 electrolytic plate. This may be due to a difference in the enamel. The bonderized ends are satisfactory for Maine sardines in oil.

Can size: 1/4 oil. Process: 150 minutes at 212° F.

Code	Date Packed	Plate		Storage at 90° F. Number of cans stored	Storage at 90° F. Days to commercial failure	Storage at 70° F. Number of cans stored	Storage at 70° F. Days to commercial failure	Date pack discarded	Remarks
	1944	Bodies	Ends					1945	
164	Jan. 20	0.125 acid melt. elect. BSE	0.125 acid melt. elect. BSE	50	No failure	50	No failure	June 27	Sulfide staining light on body, trace on ends. Peeling moderate on body, trace on ends.
165	Jan. 20	0.5 acid melt. elect. IE	Enameled bonderized	50	No failure	50	No failure	June 27	Sulfide staining trace, light peeling on body only.
166	Jan. 20	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	50	No failure	50	No failure	June 27	Sulfide staining increased from light to moderate at second examination, then showed no further increase.

Shad: Table 21. Two types of cans were used, namely, 0.125 electrolytic plate, both sides enameled, and 0.5 electrolytic bodies with bonderized ends. Two different types of enamel were used with each plate. All packs were more or less satisfactory, but as may be noted from table 21, code number 6050 gave better results than code number 6052, and 6051 was superior to 6053. Deterioration did not increase during the storage period.

Can size: No. 1 tall (301 x 411). Process: 90 minutes at 242° F.

Code	Date Packed	Plate: Bodies	Plate: Ends	Storage at 90° F.: Number of cans stored	Storage at 90° F.: Days to commercial failure	Storage at 70° F.: Number of cans stored	Storage at 70° F.: Days to commercial failure	Date pack discarded	Remarks
	1944							1945	
214* (6050)	June 6	0.125 acid melt. elect. BSE	0.125 acid melt. elect. BSE	24	No failure	24	No failure	July 18	No sulfide stain. Light enamel peeling on side seam and ends only.
(6052)		Do.	Do.	24	No failure	24	No failure	July 18	Light sulfide stain on body and ends. Light enamel peeling on side seam and ends.
215 (6051)	June 6	0.5 acid melt. elect. IE	Enameled bonderized	24	No failure	24	No failure	July 18	No sulfide stain. Moderate enamel peeling on side seam only.
(6053)		Do.	Do.	24	No failure	24	No failure	July 18	Moderate sulfide stain on body only. Enamel peeling.

* Three types of enamel were used. Codes 6052 and 6053 have one type. Code 6050 and the ends of code 6051 have a second type. The body of 6051 has a third type.

Shrimp, wet-pack: Table 22. The 1.25 OPM plate with striped side seam showed about the same degree of sulfide stain as in the previous year's pack without the side seam stripe. Enamel peeling was somewhat lighter. The 0.25 electrolytic plate showed less sulfide stain inside than the 1.25 OPM plate. The 0.5 electrolytic bodies were stained to about the same degree as the 1.25 plate.

Can size: No. 1 standard (211 x 400). Process: 13 minutes at 250° F.

Code	Date Packed	Plate: Bodies	Plate: Ends	Storage at 90° F.: Number of cans stored	Storage at 90° F.: Days to commercial failure	Storage at 70° F.: Number of cans stored	Storage at 70° F.: Days to commercial failure	Date pack discarded	Remarks
	1944							1945	
207	May 26	1.25 OPM IE inside side seam striped	1.25 OPM IE	24	No failure	24	No failure	July 16	Sulfide stain moderate on body and ends. Enamel peeling moderate on body, side seam and ends.
208	May 26	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	24	No failure	24	No failure	July 16	Sulfide stain light on body and ends. Enamel peeling light on body, side seam and ends.
209	May 26	0.5 acid melt. elect. IE	Enameled bonderized	24	No failure	24	No failure	July 16	Sulfide stain moderate on body and ends. Enamel peeling light on side seam and ends, none on body.

Tuna, yellowfin: Table 23. The 0.25 electrolytic plate, both sides enameled, is perfectly satisfactory, showing less sulfide stain and enamel peeling than the 1.25 OPM plate inside-enameled. The cans with 0.5 bodies and bonderized ends had no sulfide stain. Moderate enamel peeling of the side seam appeared at the first examination, but deterioration did not increase during following examinations.

Can size: 1/2 tuna (307 x 113). Process: 75 minutes at 242° F.

Code	Date Packed	Plate: Bodies	Plate: Ends	Storage at 90° F.: Number of cans stored	Storage at 90° F.: Days to commercial failure	Storage at 70° F.: Number of cans stored	Storage at 70° F.: Days to commercial failure	Date pack discarded	Remarks
	1943							1945	
193	Dec. 15	0.25 acid melt. elect. BSE	0.25 acid melt. elect. BSE	24	No failure	24	No failure	July 5	Sulfide stain trace on body and ends. Enamel peeling light on body, side seam and ends.
194	Dec. 15	0.5 acid melt. elect. IE	Enameled bonderized	24	No failure	24	No failure	July 5	No sulfide stains. Moderate enamel peeling on side seam only.
195	Dec. 15	1.25 OPM IE	1.25 OPM IE	24	No failure	24	No failure	July 5	Sulfide stain light on body and ends. Enamel peeling light on body, complete on side seam, moderate on ends.
196	Dec. 15	1.25 OPM plain	1.25 OPM plain	24	365	24	440	July 5	All cans swells by March 2, 1945.

CONCLUSIONS

1. A previous conclusion as to the inadvisability of using 1.25 OPM plain containers for fishery products is confirmed by results from repeat packs in the experimental series for 1943-44.

2. The 0.25 acid electrolytic plate, both sides enameled, was satisfactory for all fishery packs prepared in this plate.

3. It is believed that a different enamel would result in less staining of the plate and peeling of the enamel with packs of hard clams, New England clam chowder, and fish chowder.

4. Packs of salmon, California sardines, Maine sardines, and shad made in 0.125 electrolytic plate cans, both sides enameled, gave satisfactory results. It is believed that this plate may be used successfully for packing most canned fishery products.

5. Cans with soft clams show much less sulfide stain than those with hard clams or mussels, using the same lots of containers.